DESIGN AND FABRICATION OF COCONUT DEHUSKING MACHINE

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CERTIFICATION

This is to certify that this project work was carried out by DIOMUKORO BENJAMIN AKPESIRI with matriculation number ENG1604230, OKHIKU IKHIDE VICTOR with matriculation number ENG1503923, OKOTIE OMAJUWA with matriculation number ENG1604268 and OYOMWAN AIGUOSATLE ANTHONY with matriculation number ENG1709534 in the Department of Mechanical Engineering, Faculty of Engineering, University of Benin, Benin City in partial fulfillment of the requirement for the Award of Bachelor of Engineering (BEng.) in Mechanical Engineering.

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DEDICATION

This project work is dedicated to God almighty for his love, mercy, grace and guidance throughout our stay in school and through this project work. We would also like to appreciate our parents for the love and support both emotionally and financially.

ACKNOWLEDGEMENT

We would love to express my gratitude and appreciation to all those who gave me the possibility to complete this report. Special thanks are due to my supervisor Eng. Noel Igbinomwanhia whose help, stimulating suggestions and encouragement helped us in all time of autocad design, fabrication process and in writing this report. We also sincerely thanks for the time spent proofreading and correcting many mistakes

We would also like to acknowledge with much appreciation the crucial role of the staff in mechanical laboratory, who gave us the permission to use the laboratory equipment, the machine and to design the drawing and giving permission to use all the necessary tools in the laboratory.

ABSTRACT

Coconut is a cash and food crop that has the abaility to be grown even in bad weather, hence can be cultivated around all weathers and in virtually any geographical location in Nigeria. However; there are growing concerns of its judicious and profitable cultivation and post-harvest processing despite its commercial value as it can be consumed as food and its constituent parts can be used in pharmaceuticals, beverages, energy and power and a host of other products such as brooms, mats, floor mats. Prior to its use the coconut fruit is dehusked to remove its outer fiber shell. The dehusking process which conventionally involves the use of human effort using a sharp object is characterized by low output, susceptibility to injury and unhygienic nature.

To mitigate these setbacks, a coconut dehusking machine was designed and fabricated using the design methodology of reverse engineering. The machine had some components which include hopper, twin shafts with dehusking spikes, pulleys and pulley belts, bearings and a structural frame.

Test and operational performance carried out on the machine showed that it was quite effective for dehusking various sizes of coconuts with a throughput capacity of 33 coconuts per hour. The efficiency of the machine was estimated as 83.3%. Effectiveness of the dehusking process was dependent on the dehusking force of the machine and the moisture content of the coconut fiber. A major advantage and achievement in this prototype was that more than one coconut could be dehusked simultaneously and the dehusked coconuts can be discharged automatically without the input of human effort.

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CHARPTER ONE

INTRODUCTION

1.1 Background to the study

Coconut belongs to the palms family with is scientific name known as (Cocos nucifera). It is fondly referred to as the "tree of life" cultivated in many countries around the world with Indonesia, the Philippines and India ranking as the Topmost producers of the crop in the respective order. It is a food crop as well as a cash crop (Warner, 2007). with many vital components for use in the production of other products such as oil, cookies, sponges, combustion fuels etc. Coconut farming though being a cash-tree, it however receives very little attention in Nigeria. Coconut as a food and cash crop cultivated in Nigeria can adapt to many soil types and climates. It has a good resistance to bad weather conditions which enables it to produce continuously from the age of 4 or 7 years to 60 years. Coconut farming has a wild range of industrial application of most of the products. though the crop is not predominantly indigenous to Nigeria, the country is however blessed with varieties of coconut trees which could be harnessed for industrial development through which the quality and standard of living of the people can be improved. (Okoroi, 2020)

Coconut production in Nigeria if given the proactive attention it requires has the potential to be an industrial and economic springboard from which the country can develop its value chain in food and other materials production. In Nigeria there has been several opportunities explored by individuals in the processing and packaging of coconut products used in pharmaceuticals, cosmetics, beverage, delicacies like chocolate, cookies, crepes, candy etc. Fuel and charcoal can be produced from the husks (outer fibre shell) and coconut hard shells the natural elastic fiber known as coir taken from coconut husks, can be used to make ropes, floor mats, strings, brushes.

The leaves of the crop are used to make baskets, brooms, roofing thatches and sun sheds. (Emeaghalu, 2018). Coconut water has gained popularity as refreshment which is also utilized as a sports drink considering energy calorie value. The coconut tree shown in Figure 1.1 stands tall and can reach height well above 15 feet and some other varieties can be short of dwarf in nature reaching heights barely above.

Figure 1.1 A coconut tree

In many urban and rural areas in Nigeria, a huge number of people involve in coconut dehusking process in order to extract the fruit's component parts. The coconut fruit is oval in shape with various layers of its components parts as shown in the Figure 1.2.

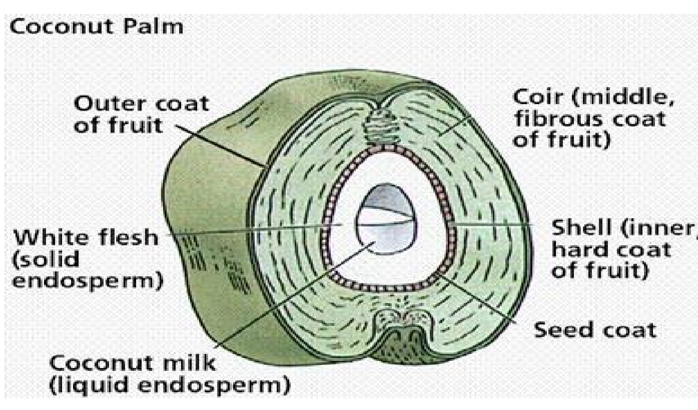


Figure 1.2 Coconut fruit with its parts

Coconut dehusking also commonly referred to as deshelling by many authors is the process of removing the outer spongy fiber or shell of the coconut. The process conventionally involves the use of sharp tools which consumes more time and human energy who engage in the process with their hands. The conventional method is also risky, unhygienic and unproductive in terms of bulk production. The human dehusker is highly susceptible to injuries. Following these setbacks, mechanical means of dehusking coconuts have been devised. The present project therefore aims to review typical coconut dehusking machines and also produce a viable prototype that could be an optimized version of the existing coconut dehuskers.

1.2 Statement of the problem

Coconut cultivation and use in Nigeria has the capacity to grow the country's economy if given the required attention. The crop is a cash and food crop that has the resistance to grown even in bad weather, hence can be cultivated around all weathers and in virtually any geographical location of the country. However; there is growing concerns of its judicious and profitable cultivation in Nigeria despite its commercial value as it can be consumed as food and its constituent parts can be used in pharmaceuticals, beverages, energy and power and a host of other products such as brooms, mats, floor mats. Prior to its use the coconut fruit is dehusk to remove its outer fiber shell. The dehusking process which conventionally involves the use of human effort using a sharp object is characterized by low output, susceptibility to injury and unhygienic. It is in the respect of mitigating such setbacks that various coconut dehusking machines have been devised by researchers and engineers. These machines however have their individual advantages and disadvantages. The present research therefore intends to review some of these commonly used machines with the aim of reproducing and optimizing one of the viable prototypes.

1.3 AIM AND OBJECTIVES OF THE RESEARCH

1.3.1 Aim of the Research

The aim of the present research is to review, design and fabricate a coconut dehusking machine using locally sourced materials for optimized operation.

1.3.2 Objectives of the research

The objectives of the research are

1. To review some viable concepts of coconut dehusking machines
2. Develop concepts of coconut dehusking machine
3. Fabricate a viable coconut dehusking machine prototype
4. Test the fabricated coconut dehusking prototype.

1.4 **Scope of work**

The scope of the present study involves design and fabrication of a coconut dehusking machine for small scale coconut dehusking. The dehusking machine is to be designed to remove the outer spongy fibre or shell covering the hard-inner nut. The proposed prototype machine will be fabricated using locally sourced materials and can be deployed in urban and rural areas for use by subsistence and commercial farmers in Nigeria.

1.5 **Significance of the work**

The significant of the project work include the followings;

i. The ability to produce cheap and small-scale coconut dehusking machines which can be a source of income and job for Nigerians.

ii. Coconut dehusking machines are useful machineries for rural and urban farmers, hence its production locally will promote agricultural investment, create wealth and employment as well as increase the gross domestic product (GDP) of Nigeria.

iii. The production of coconut dehusking machine locally will boost the local content initiative of Nigeria as part of the federal government of Nigeria economic plans.

1.6 METHODOLOGY

The method for achieving the aim and objectives of the project include the followings:

1. Literature review of the study
2. Feasibility studies of the project
3. Conceptual design and analysis.
4. Detailed design of prototype
5. Fabrication of prototype
6. Testing of the fabricated prototype
7. Conclusion and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Coconut Production

Coconuts are one of the most widely cultivated palm trees in the world, with Indonesia, the Philippines and India each being the world's largest coconut producers. It is affectionately known as the "Tree of Life". As a direct source of money, food and materials, it plays an important role in the livelihoods of smallholder farmers (Warner, 2007). Coconut extract is industrially processed in Nigeria to make cosmetic body lotions, creams, fruit drinks, and even vinegar.Coir, a natural elastic fiber from the coconut shell, is used to make doormats, brushes, Can be used to make ropes, cords. Coconut leaves can be used to craft brooms, baskets, thatch roofs, and makeshift huts. Coconut wood is used in the construction of houses and furniture (Emeaghalu, 2018). Coconut palms originate from the humid tropics, not from agriculture in Nigeria. It grows under a variety of climate types and is known to be very adaptable, but it usually grows in shallow soils along the coast and, with the help of its husky exocarp, can stay in the sea for months. They float and can germinate even if stuck.Thus, they may have originated somewhere between the East Indies and the West Pacific.

In Nigeria, an estimated 15,000 hectares of land are cultivated for coconut, mainly in the coastal areas of Lagos State and the delta areas of Rivers State (Akpan 1994). An estimated 1.2 million hectares have been identified elsewhere in the country as suitable for coconut cultivation. Before the Age of Discovery, coconuts spread from East Africa to the Pacific coast of Panama. Coconuts were the sole source of food and water for many businesses across the equatorial Pacific, and the natural distribution of coconuts may have influenced early settlement of the region. For example, Lagos State has the potential to produce over 10 million coconut trees, with over 1 billion in-shell nuts worth Np45 billion and less than 1,500 tonnes of coconut oil production used annually. I'm here. According to the US Department of Agriculture (2016), domestic consumption of coconut oil in Nigeria is around 7,000 tons, creating a supply gap of around 5,500 tons per year. It is against this background that the federal government has developed special attention on the crop and agricultural sector at large with the main targets of promoting investment, production and productivity as well as ensuring food security thus, improving the livelihoods of coconut farming communities (URT, 2002). There are low yields of the crop in Nigeria despite the government's various intervention tools as various factors are responsible for it.

The inadequate supply of implements and inputs, low rate of adoption of new technology by farmers, lack of technical knowhow, perceptions about methods, land constraints, lack of loan ageing labour, post-harvest technology problems, disease and pest management problems and other natural hazards are major factors contributing to the low yield of coconut in Nigeria. (Okoroji et al, 2020). The problems faced by the Nigerian coconut farmers are legions that needs to be tackled headlong before severe hunger typified by poverty and lack of adequate nutrient become real. Of these problems, funding for production appears insufficient to meet the country's food production needs. Other issues are rooted in equipment availability, cost (Ndubizu 2003) and adaptability. Coconut production around the world is shownTable 2.1 Top coconut producing countries (2010-2014)

Countries	Coconut production (billion nuts/year)				
	2010	2011	2012	2013	2014
India	16.9	16.9	23.4	22.7	21.7
Indonesia	16.2	16.2	16.3	16.5	16.4
Philippines	15.5	15.2	15.9	15.4	14.7
Brazil	3.4	3.5	2.9	2.9	2.9
Sri Lanka	2.6	2.7	2.9	2.5	2.9
Papua New Guinea	1.5	1.5	1.5	1.5	1.5
Vietnam	0.8	0.9	1.2	1.2	1.2
Mexico	1.4	1.4	1.1	1.1	1.1
Thailand	1.0	0.8	0.8	0.8	1.0
Malaysia	0.6	0.6	0.6	0.6	0.7
World	65.6	65.4	72.1	70.9	69.8

Source: APCC (2016)

The exportation and importation of products made from coconut as a by-product by yearly estimate are also shown in the Table 2.2

Table 2.2 World export and import of major coconut products (2010-2014)

Products	2010	2011	2012	2013	2014
Coconut oil					
Export (tonnes)	2 417 041	1 860 582	2 083 854	2 230 963	2 190 911
Import (tonnes)	2 587 567	2 109 062	2 018 441	2 462 181	2 065 444
Copra meal					
Export (tonnes)	1 014 463	611 710	1 060 417	1 184 585	866 441
Import (tonnes)	1 138 907	614 555	675 445	674 995	291 608
Coir and coir products					
Export (tonnes)	299 820	304 505	296 701	290 654	331 021
Import (tonnes)	769 978	871 865	933 601	905 538	1 021 916
Desiccated coconut					
Export (tonnes)	354 485	386 286	360 916	386 319	440 983
Import (tonnes)	301 435	308 775	313 108	478 658	502 148

Source: APCC (2016)

The development of produce and products of coconut over a recorded timeline is also shown in the Table 2.3.

Table 2.3 Development of traditional and new emergence coconut produces and products

Fresh produces	*Coconut oil*	*Detergent/ healthcare*	*Processed food*	*Non-food*
A). Traditional coconut products (prior to 1994)				
Fresh coconuts	Cooking oil	Toilet/ bath soaps	Coconut vinegar	Coco chips
Matured coconuts	Alkanolamide	Laundry soap	Nata de coco	Coco lumber
Dehusked nuts	Glycerine		Paring oil	Coconut shell
Kopyor/ makapuno	Others oleochemical		Coco cream powder	Coconut shell charcoal powder
Coconut water			Frozen coco meat	Coco coir waste
Coconut milk			Shortening	Coco husk
Coconut seedlings			Desiccated coconut	Coco husk chips
				Coco coir fibre
B). New emergence coconut products (1994-2016)				
		Shampoo	Coco jam	Coco handicrafts
		Soap chips	Special creamed coconut	Coco shell powder
			Coconut water concentrate	Coco wood pallet
			Coconut milk powder	Coco fibre dust
			Coconut liquor	Coir net
			Coco sauce	Coir doormats
			Grated coconut meat	Coir twine
			Coconut honey	Coir pads/ liner
			Margarine	Coco husk cubes
			Coconut flour	Activated carbon
			Hydrogenated coconut oil	
			Virgin coconut oil	

Source: Salum (2017a)

Nigerian National Coconut Growers Processors and Distributors Association by visionary stakeholders in the Nigerian coconut value chain industry on 30th August 2018 to promote the cultivation and production of coconuts and their products was established. These visionary stakeholders laid the solid foundation from which the Society extended its tentacles. The Nigerian Coconut Growers Processors and Distributors Association is duly registered with the

Nigerian Business Affairs Commission after receiving approval from the Ministry of Industry, Trade and Investment. The National Coconut Producers and Marketers Association of Nigeria (NACOPPMAN) is the umbrella organization to regulate the Nigerian coconut industry for the benefit of all stakeholders including coconut growers, processors, marketers and the government at large. has primary responsibility for

The Nigerian National Coconut Growers Processors and Distributors Association (NACOPPMAN) and the Nigerian Coconut Research Institute (CORIN) have been established to introduce improved agricultural technology packages within the coconut-based farming system. Technologies presented were coconut seed varieties, integrated pest management, agricultural practices, and processing techniques. These techniques aim to improve household incomes of smallholder farmers through increased crop productivity, resulting in increased incomes at the household level (Emeaghalu, 2018). NACOPPMAN got off to a flying start in 2018 with the main aim of making Nigeria the coconut production hub of Africa. consumer needs. Therefore, this study aims to assess the economic prospects of improved coconut production and its impact on Nigeria's economic prosperity.The problems facing Nigerian coconut farmers are numerous, with poverty and Acute hunger, characterized by a lack of adequate nutrients, must be addressed first before it becomes a reality. Of these problems, funding for production appears insufficient to meet the country's food production needs. Other issues are rooted in equipment availability, cost (Ndubizu 2003) and adaptability.

2.2 Coconut dehusking process and machines

The coconut dehusking process usually involves removing the outer spongy fibers or shell of the coconut from the hard-inner fruit of the crop, using hard and sharp objects such as knives and spears. These traditional methods, later morphed into some modern methods, have long been described at various stages of development: Rey (1955) turned on the rotation of the cam to Coconut meat finely crushed by. Blandis and Glaser (1973) used pressurized water to separate the coconut pulp from the husk. Even in large processing facilities, about 15 to 20 workers are used to shell 20,000 to 30,000 nuts, making the method labor intensive and requiring several to separate the shells and copra. It takes time (Singh, 2004). Navaneethan et al. (2020) argued that coconut shelling is one of the most difficult and time-consuming post-harvest tasks. In other words, we need to recognize or create a suitable system to process a huge number of coconuts. This has led to several efforts to motorize coconut dehusking. Some of these machines work physically, others work by force each with its own preferences and drawbacks. A typical coconut sheller consists of a series of rollers fitted with spikes. These rollers are connected to gears for power transmission. This process is much faster and easier than the manual process. The rollers are placed parallel to each other and fixed with spikes. The spikes are used to hold the outermost part of the coconut, i.e. the bottom of the coconut husk to remove. The rollers are coupled to the shaft using an arrangement of bearings and gears. The rollers are then rotated in the opposite direction, thereby carrying out the deshelling process. A motor with a suitable output speed will work. Dynas etc. (1987) reported that a machine intended solely for shelling coconuts consisted primarily of rollers rotating in suitable opposite directions, each roller penetrating a coconut shell segment and claimed to contain multiple penetrating spikes that were polished to permanently bond with the The connection of the rollers is mixed with the holding action of the mandrel. The mandrel tears the shell from the nut, leaving the nut as a self-contained mass.

2.3 Review of Literatures on coconut dehusking machines

Following advances in coconut dehusking operation various researchers have made significant contributions towards showcasing various techniques for the task. Some of the works of these researchers are highlighted as follows; Thomas et al, (2017) designed and produced an automatic coconut dehusking machine shown in Figure 2.1 with the ability to load and unload un-dehusked and dehusked coconuts of varying sizes respectively. The experimental prototype of the machine consisted of a frame on which other components were mounted. The dehusker was situated at the center which delivered motion with the help of a motor and the chain drive. Also, at the top of the dehusker, a plate was used to place the coconut on the rollers which had spikes, the rollers were connected with shafts which were rotated by an electric motor. The shafts rotated in counter directions which initiates the peeling of the husk due to the opposing motion of the rotating rollers.

Figure 2.1 the Thomas et al (2017) coconut dehusking machine

The rollers had spaced spikes attached to its outer surface which helped to prevent the slipping of the coconut fibres and the coconut itself during the dehusking operation. The dimensions of cylindrical rollers were designed in a manner to obtain effective mesh with coconut husk. Assumptions made by the authors in order to design the machine included the coconut contacts with cylinder at an average angle of 30-degree contact sector and the 1/6th of width of coconut should be inserted into the intermediate space between cylinders that was an approximate of 30mm of the coconut assumed uniform diameter. The authors asserted that the machine had the advantages of being easily moved from one place to another and cheap to produce. Pande et al (2016) designed and fabricated a coconut dehusking machine shown in the Figure 2.2. The main dehusking component of the machine was a wood sawing cutter attached centrally to a rotating shaft mounted on the machine frame via two pillow bearings on opposite sides.

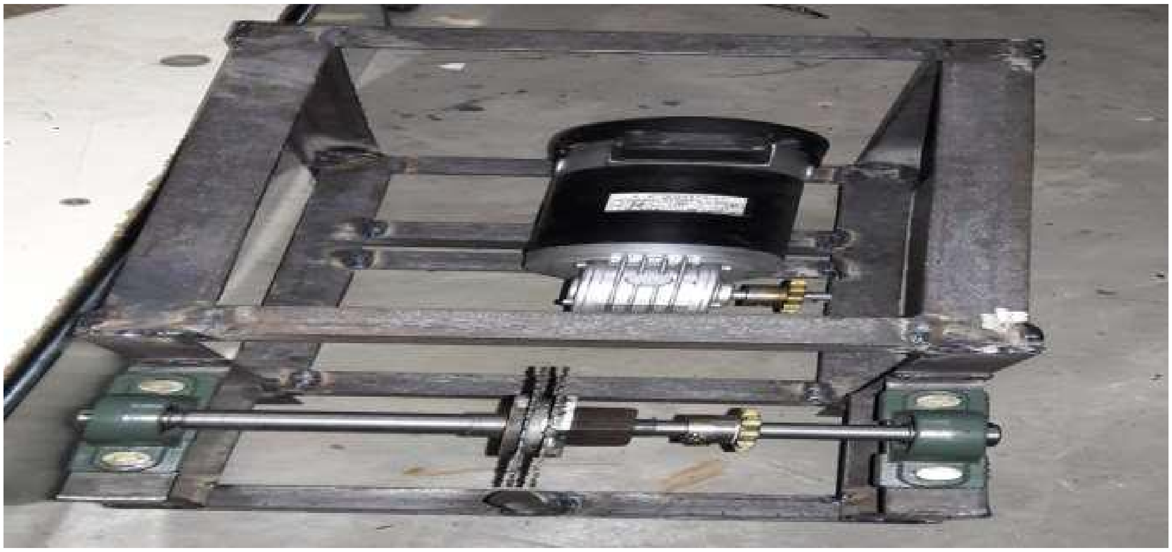


Figure2.2 the Pande et al coconut dehusking machine (2016)

Tonpera. (2016) conducted a performance analysis of a coconut sheller and then designed and manufactured a prototype. The main components of the coconut sheller shown in Figure 2.3 were the frame, sheeter, conveyor unit, drive pulley and drive pulley, rubber belt, motor and bearing housing. The frame was the main supporting structure to which the other components of the machine were attached. The frame was a welded construction of 50x50x5 mm angle steel with a length of 650 mm, a width of 740 mm and a height of 1000 mm. The peeling unit consisted of three shafts, two of which were intermediate shafts and one was a knife shaft. The intermediate shaft was a 25 mm diameter, 610 mm long mild steel bar, and the attached cutting shaft was 25 mm diameter and 250 mm long, supported by ball bearings at each end. A 1 horsepower (0.745 KW) induction motor mounted at the base of the stand transmitted power from the motor shaft to the #3 intermediate shaft via single-slot pulleys fixed to the motor shaft and intermediate shaft respectively . The motor shaft rotated at 1440 rpm and the intermediate shaft at 643 rpm. Due to the low strength of palm shells, a low speed was required for cutting.

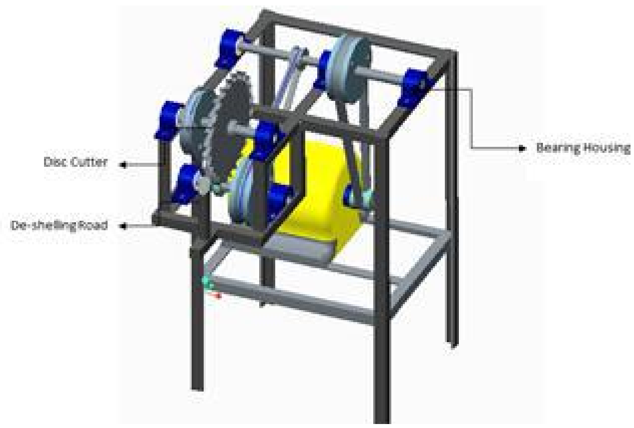


Figure 2.3 Tonpe et al (2016) coconut deshelling machine

Jambhulkar et al (2019) designed and developed a coconut de-shelling machine shown in Figure 2.4.

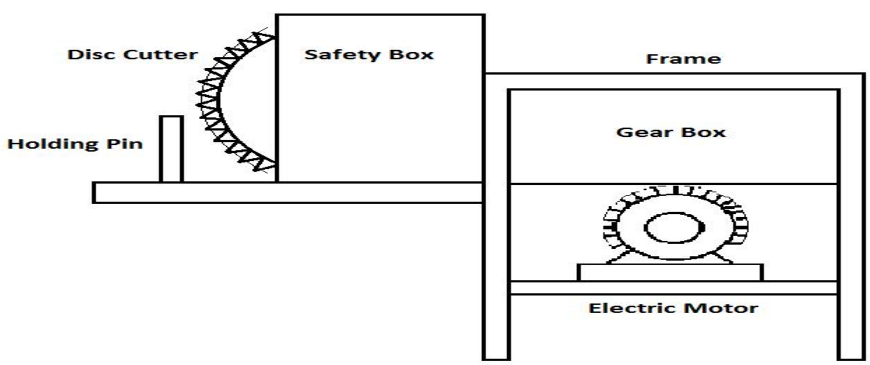


Figure 2.4 Jambhulkar et al (2019) coconut deshelling machine

The machine's dehulling unit consisted of an intermediate shaft and a cutting shaft driven by an AC motor. When AC power is applied to the motor, the mechanical force of the motor causes the shaft to rotate. This movement is transmitted to the intermediate shaft attached to the pulley, and the deceleration power is transmitted to the intermediate shaft. The cutter rotated clockwise near the bar of his knife. To force the shelling process, I held the coconut in my hand and brought the coconut eye closer to the shelling stick without touching the slicer. Hold the coconut fruit firmly and gently tilt it towards the slicer until the shelling process begins. The peeling process continued reliably.

Singh and Udhayakumar (2014) designed and developed a powered machine for coconut shelling. Machine capacity was 200 nuts or 400 cups per batch. Loading and unloading was done manually. The optimal average moisture content for maximum rice husk efficiency (92%) was 35% (db.). The optimum rotation speed of the dehuller was 10 rpm and the time required for dehulling was 4 minutes per batch. Using the peeler saves 4x the time compared to the manual method.

Rattanapaskorn and Roonprasang (2014) analyzed the feasibility of designing and developing a semi-automatic crusher for young coconuts. The purpose of their research was to design, manufacture, test and evaluate a prototype semi-automatic coconut sapling cutting machine. The design concept was that the cutting of the fruit would be achieved by a pneumatic press of young coconuts resting on a sharp knife on a vertical plane. When turned on, the coconut automatically moved to the dehulling unit and was cut in half by a knife set. While the cut fruit was separated and transported to another tank, the coconut juice flowed into the tank. The machine was found to work safely without harming the fruit. The machine had a throughput of 480 fruits per hour and a total cost of ownership of approximately $2.63 per 1000 fruits.

CHAPTER THREE

MATERIALS AD METHOD

3.1 Materials

The materials required for experimentation and production of coconut dehusking machine include coconut specimen, measuring tools, metal fabrication tools, machining tools, bearings, metal, reduction gear, electric motor.

3.2 Method

Determination of physiological properties of coconut shown in Table 3.1

Table 3.1 Physiological properties of coconut. Thomas et al (2017).

Particulars	Remark
Texture	Dry
Shape	Ovoid
Average weight kg	0.62-1.25
Length mm	210-270
Diameter mm	160-206
Husk Thickness-at apex end, (mm)	34
Husk Thickness-at pedicel end, (mm)	62
Husk Thickness-1/4 distance from pedicel end, (mm)	32
Husk Thickness-1/2 distance from pedicel end, (mm)	24
Husk Thickness-3/4 distance from pedicel end, (mm)	28

3.2.1 Conceptual design

Various concepts of coconut dehusking machines were considered and choice of a most viable concept will be selected based on some criteria which include less input of human effort. Two concepts are therefore considered for selection and they are the motorized dehusking and the manual dehusking machine. First the design inputs and considerations have to be itemized, tabulated and scaled on a decision matrix as shown in Table 3.2.

Table 3.2 Decision matrix for coconut dehusker concepts

Design criteria		
	Concept 1 Human cranked coconut dehusker	Concept 3 Motorized dehusker
Elimination of human effort	1	2
Low cost of production	2	1
Simplicity	2	1
Ergonomics	1	2
Ease for continuous flow	1	2
Total	7	8

Following the design factors considered, the motorized coconut dehusker would be more viable for design. The adopted concept 2 with highest grading of criteria of 8 eliminates human effort hence will have higher product output. It will consist of the following parts:

i. Frame

ii. Chain and sprocket

iii. Reduction gear

iv. Shaft

v. Abrasive rollers with spikes.

vi. Roller bearings

vii. Pulley belt,

viii. Pulley

The machine operation will be such that when a dried coconut is loaded in between two opposite rotating abrasive drums with spikes, it is dehusked by an abrasive mechanism where the spikes gradually tear the husk fibers apart from the coconut. The coconut is positioned on the drums or rollers with $1/6^{th}$ of its entire oval surface enmeshed on the space between the two rollers for optimal dehusking process. (Thomas, 2017).

3.3 Detailed design

I. Dehusking force of coconut required force to detach the husk fiber from the hard shell. is given as

$$F = P/v \qquad 3.1$$

Where P = power required to dehusk coconut and was equated to 674.68W by (Nwankwojike et al, 2012).

v = speed of driving roller = $\frac{\pi ND}{60} = \frac{3.142 \; x \; 100 \; x \; 250}{60} =$

where D = is pitch diameter of the driving gear, N = number of turns of gear per minute

For good shelling output, N ranges between 65 – 100rev/min (Sangital et al, 2019).

Taking the upper bound for v, then F from equation 3.1 can be evaluated as

F = $\frac{674.68}{1309}$ = 0.515N

Considering the distance between the meshing gears which should accommodate 1/6th of the coconut diameter, therefore each gear should be spaced from the other by 206/6 = 34mm

Adding this to the spike length of 10mm on both rollers plus depth of rollers = 74mm.

Therefore, center to gear tooth of rollers = $\frac{74-34}{2}$ = 20 and diameter of gear = 40mm

Since the same gears will be used for the driver and driven gear, it follows that gear ratio = 1.

The power to the shaft attached to the dehusker as is supplied by an electric powered reduction gear motor.

II. Feed hopper design

Volume of the hopper bucket (for trapezoidal hopper) = Area of one face of shape configuration of hopper x Height i.e.

$$V = A \times H \qquad 3.2$$

The hopper volume is designed to be large enough to accommodate variable sizes of coconut with capacity of maximum of 3 coconut loaded and dehusked simultaneously. v

Volume of the hopper bucket; area of the trapezoid face = ½ (sum of parallel sides x height) x horizontal length of hopper. height i.e ½ (0.2+ 0.3) x 0.3 x 0.4 = 0.03m^3

V. Torque T required to drive the abrasive shaft with spikes

$$T = \mu \times F \times r_m \qquad 3.3$$

Where; μ is frictional coefficient between metal spikes and coconut = (3.02),

r_m = mean radius of spike

F = weight of spike (N) and

T = 3.02 x 0.5 x 0.15 = 0.227N.

VI. Diameter D of the driving shaft.

$$= \frac{16}{\pi S_s} \sqrt{K_b x M_b{}^2 + K_t \, x M_t{}^2} \quad (3.4)$$

$$= (16/3.142 \text{ x}55.8 \text{ x } 10^6) \text{ x } \sqrt{1.5 \, x \, (\frac{12.65}{v})^2 + 1 \, x M_t{}^2}$$

VII. Power supplied by belt attached to the pulley is given as ;

$P = (T_1 - T_2)V$ … (Hannah and Stevens, 1970) (3.5)

But V (velocity) = (πDN)/60 and $\frac{T_1}{T_2}$ = exp(μθcosβ),

where β = the grove semi-angle,

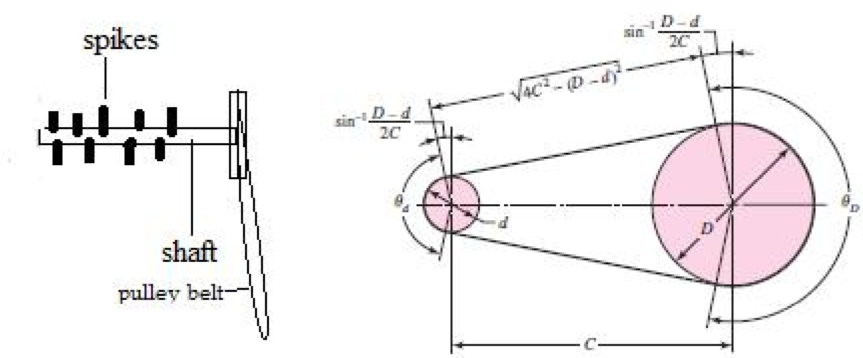


Figure 3.1 Pulley belt on pulley geometry

θ = the angle of lap =(180−2α)×$\frac{\pi}{180 \text{ rad}}$

sinα = $\frac{r_2 r_1}{x}$,

where; α = the angle of contact at the smaller pulley, x = distance between pulleys

r_1 = radius of smaller pulley, r_2 is radius of bigger pulley and

μ = the coefficient of friction.

Since ; V = (πDN)/60 and $\frac{T_1}{T_2}$ = exp(2.05)

Values may be assumed for T_1 or T_2 to completely evaluate the expression;

VIII Length of pulley; $L = 2x + (\frac{\pi}{2XD} + d) + (D - d)\,\frac{2}{4X}$. (3.5)

Where; D = diameter of bigger pulley,

d = diameter of smaller pulley

x = distance between pulleys measured from their respective centers

Length of pulley; $L = 2x + (\frac{\pi}{2XD} + d) + (D - d)^2 \times \frac{1}{4X}$.

L = 1.52m

IX Determination of the Bending Moment at each point of Loading

This involves the preparation of the bending moment diagram for the two perpendicular planes: vertically and horizontally as shown in Figure 3.2

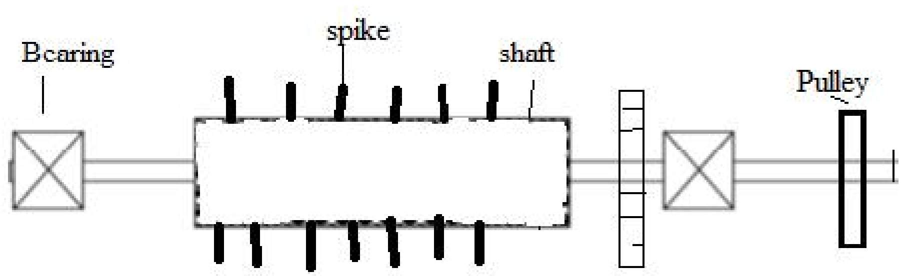
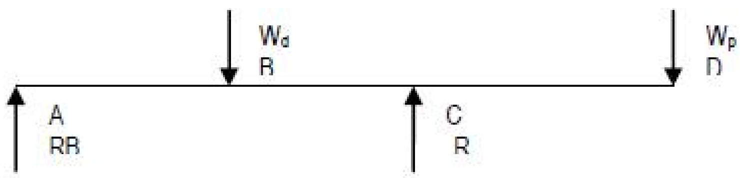


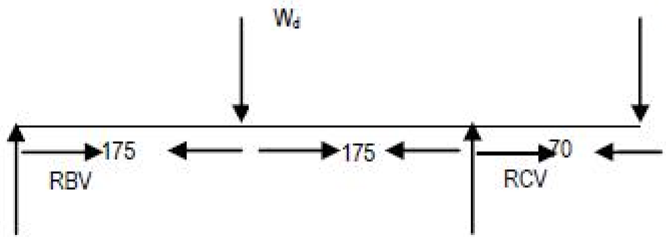
Figure 3.2 shaft bending moment determination.

Reactions at the Bearings Due to Vertical Loading

Below is represented the expected free body diagram of vertical forces acting on the shaft:



To obtain the reactions at each bearing, we will have to take moment about the two expected bearing points independently.



Taking moment about point A,

-RCV (350) + Wp (420) + 643.56(175) =0

RCV = 339.438N

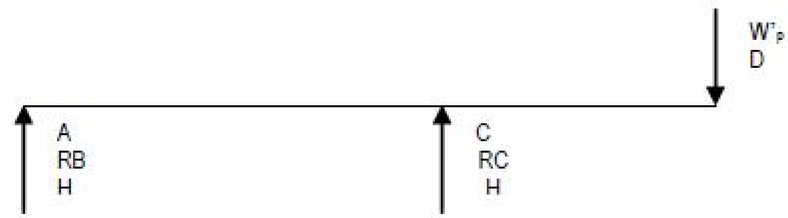
Taking moment about point B,

-643.56(175) + RBV (350) + Wp (70) = 0

RBV =318.837N

Reactions at the Bearings Due to Horizontal Loading

Below is represented the expected free body diagram of horizontal forces acting on the shaft



Where Angular acceleration ω, in rads /sec = 2πN/60

Torque = (760 x 60)/ 2π x 1440 = 4.955Nm

Horizontal weight on pulley = w'_p = 4.95/ (3 x 0.0245) = 67.35N

RBH + RCH = W'_p

Taking moment about Point A, RCH (350) = 67.35(420)

RCH = 80.82N and RBH = -13.47N

Considering the horizontal, vertical forces and the bearing reactions, the maximum bending moment then obtained from the resultant bending moment is finally quantified as follows

Resultant bending moment at point where weight of shaft acts

$= M_b = [(M_v)^2 + (M_h)^2]^{1/2}$ (3.6)

$= \sqrt{(339.438^2 + 80.82^2)} = 348.92$Nm

And at point R_2, $M_b = [(M_v)^2 + (M_h)^2]^{1/2} = 318.83^2 + 13.4^2 = 319.11$

The maximum is taken of the bending moment = 348.92Nm

Torsional moment = P/2πn. (3.7)

Where n = speed (rev/hr)

Maximum speed of the machine = 30 m/s

But 2(rad) = 1rev

Therefore, 30 m/s = 1718.18 rev/min

Hence, Mt = 23.84 Nm

The diameter of the shaft which is given as $d^3 = 16/\pi Ss[(K_bM_b)^2 + (K_tM_t)^2]^{1/2}$

Where d = diameter of shaft

Ss = allowable stress (55 MN/m2 for shaft without keyway and 40 MN/m2 for shaft with keyway

=3√62128.174 = 39.54mm

A shaft of diameter 40mm was utilized to optimize the machine efficiency since the electric motor power rating was also increased.

K_b = factor for suddenly applied load = 2 (see appendix 1)

K_t = factor for suddenly applied load = 2 (see appendix 1)

Power p = fv x (Multiply by factor of safety of 1.5)

Where, v =velocity or speed = 30m/s

f = the total forces acting on the shaft + the weight of the shaft

= (belt pulley driven electric motor + dehusking spikes + weight of coconut + shaft weight)

X Bearing selection

The alternative method of reading off from reference manual as shown in the appendix 2 of this material was adopted for this work. From appendix 2 the appropriate bearing is selected based on output speed, bore size, static load, and dynamic loads and bearing load of shaft.

Dynamic equivalent load for rolling contact bearings (DEL)

This is a constant fixed radial load (for radial ball or roller bearings) or axial load (for thrust ball or roller bearings) that gives the same life to a bearing with a rotating inner ring and a fixed outer ring. What bearings experience under real load and rotation conditions [Khurmi et al 2005]

For radial and angular contact ball bearings with a constant radial load WR combined with a constant axial load or axial load WA, expressed as W and given by

$W = X.V.WR + Y.WA$ (3.8)

From where;

V = rolling factor for all types of bearings when the inner ring rotates = 1

Also, values for the radial load factor X and the axial or thrust factor Y for dynamically loaded bearings can be found in the references or Appendix 3 of this document.

Dynamic load rating DLR for roller bearings with varying loads

It is expressed as;

$$C = W (L / 10^6)^{1/k} \quad (3.9)$$

where W= equivalent dynamic load

L= service life rating of the ball or roller bearing

The relationship between the life in revolution L and the life in working hours L_H is given by

$L = 60N.L_H$ revolutions where N I the speed in rpm

k = 3, for ball bearings and 10/3 for roller bearings

Having evaluated all factors from calculated, working condition and references, ball bearings were found suitable and used for the measuring machine.

When choosing the best ball bearing, multiply the basic dynamic radial load by the service factor (Ks) to calculate the basic dynamic radial load capacity of your design. Service factors for ball bearings can be found in the references or Appendix 3 of this document. After determining the dynamic radial load capacity of the basic design, the manufacturer's literature and reference catalogs were used to select bearings.

3.4 Bill of Engineering Materials and Evaluation

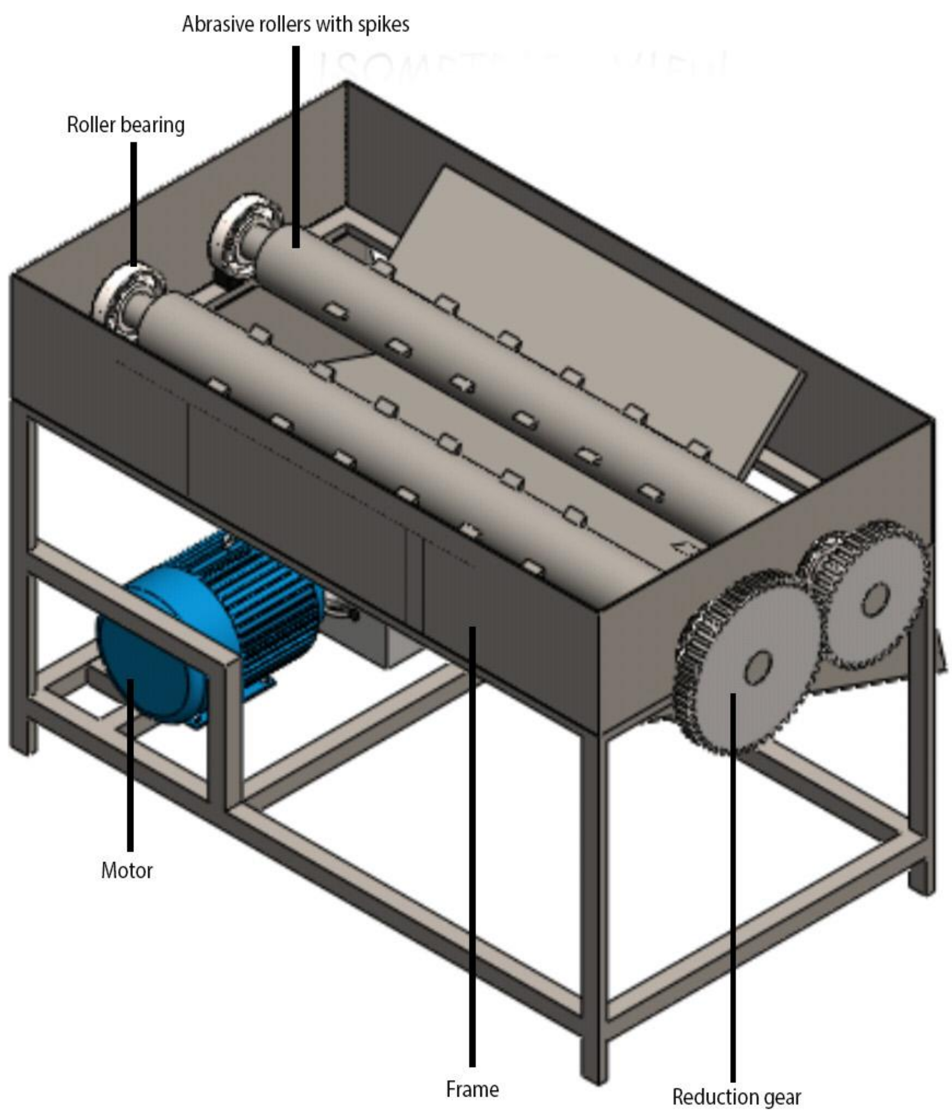
A list of engineering materials and a rating of coconut is shown in Table 3.2.

Table 3.2 Bill of Engineering materials and evaluation for coconut dehusking machine

S/No	Component	Materials	Quantity	Rate	Amount =N=
1	Motor	Electrical device	1	30000	30000
2	Reducer gear	Mild Steel	1.	20000	20000
3	Hopper, body and discharge	Mild steel sheet	3	12000	36000

	chute				
4	Metal plate	4mm thick Mild steel	2	10000	20000
5	Belt drive	Balata	1	1000	1000
6	Bolts and nuts	Mild steel	sum	5000	5000
7	Angle bars	2inch and 4 inches	3	4000	12000
8	Bearings	40mm bore ball bearings	2	5000	10000
9	Metal thongs	1-inch twisted rod	2	2500	5000
10	Paint	Liquid base	2 cans	1000	2000
11	Electricals		sum	10000	10000
12	Shaft	20mm Mild steel rod	1	3000	3000
13	Pulleys	Cast metal	2 (small and big)	5000	5000
14	Miscellaneous	Labor, transport, unforeseen	Lump sum	30000	30000
15	Total				189000

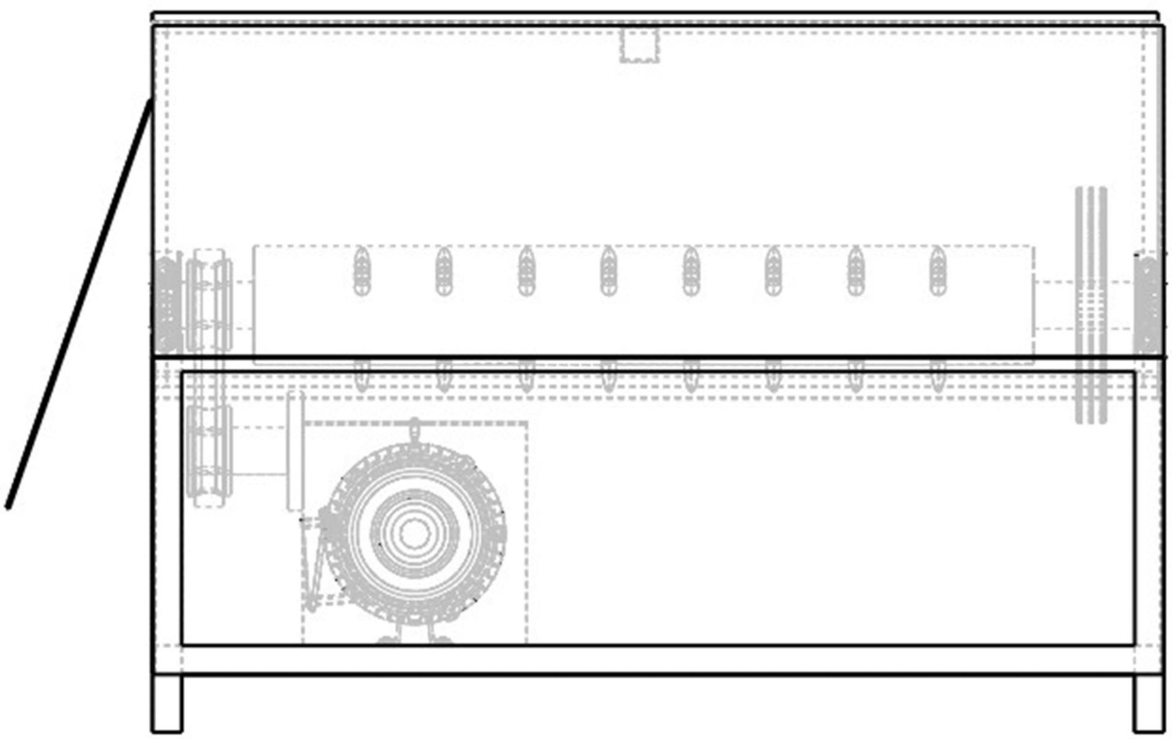
A graphic presentation of the fabricated coconut dehusking machine is shown in Figure 3.3.


Abrasive rollers with spikes
Roller bearing
Motor
Frame
Reduction gear

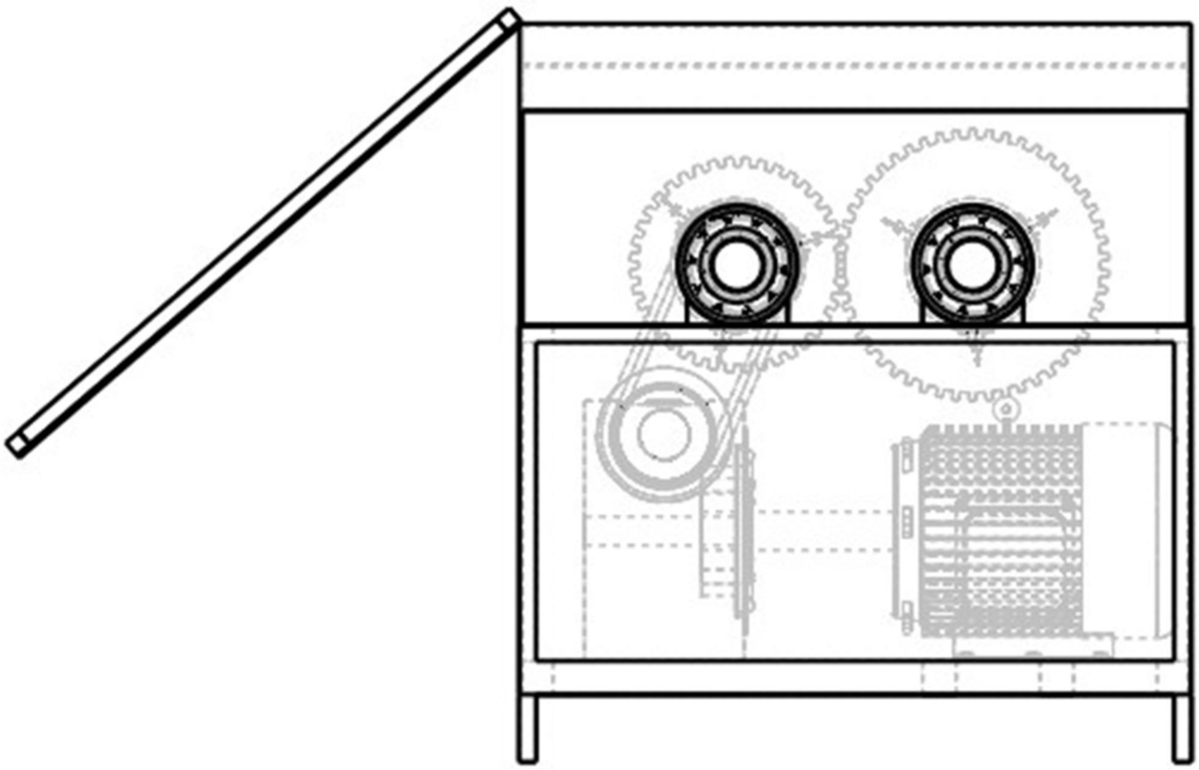
ISOMETRIC VIEW

ISOMETRIC VIEW

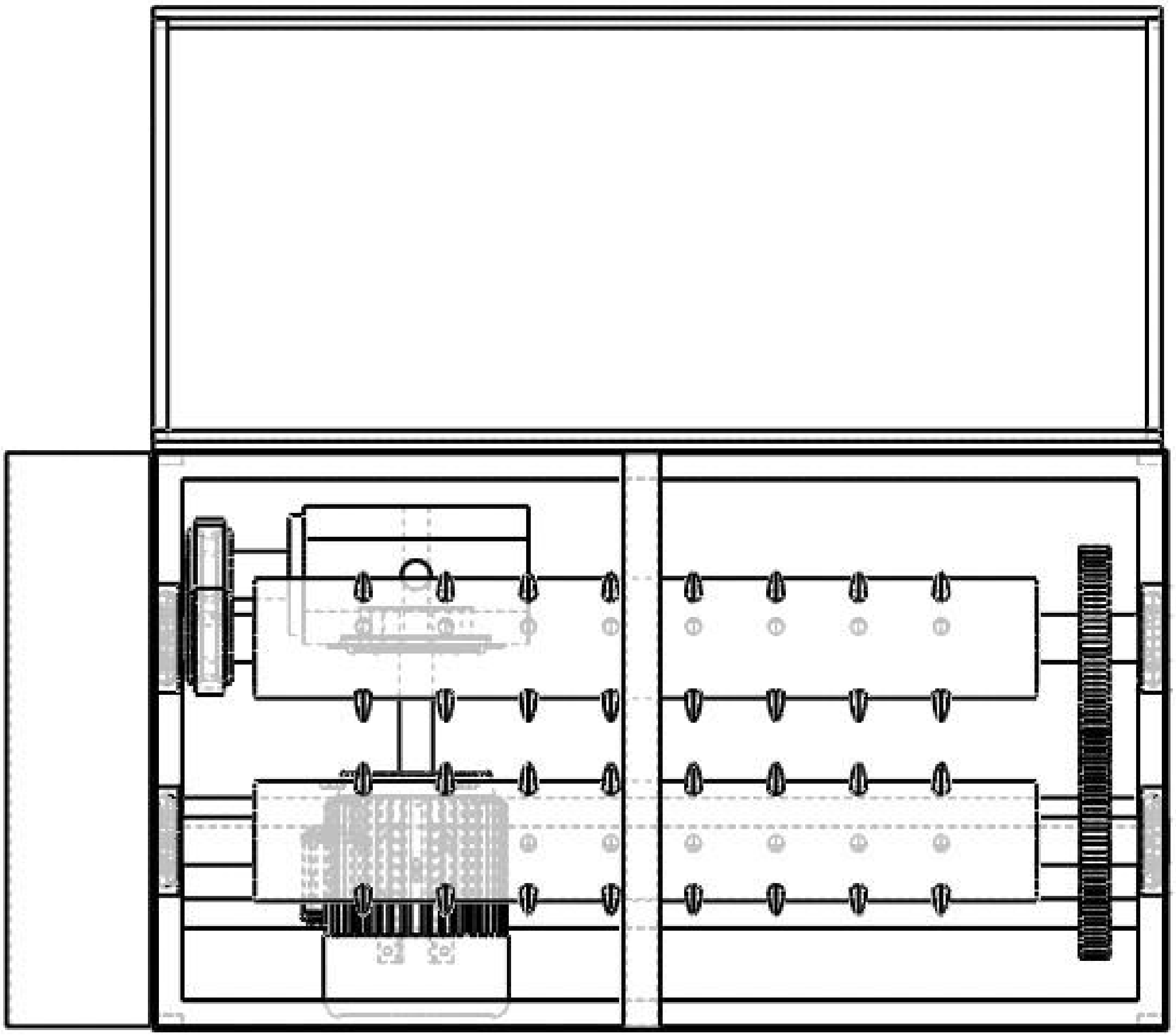
FRONT VIEW



RIGHT VIEW



TOP VIEW



CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 TEST

The coconut dehusking machine was tested for performance evaluation and operational efficiency. Known numbers of un-shelled maize coconut was loaded into the machine for onward dehusking. Different test runs were carried out and the number of well dehusked coconut and time it took for dehusking to occur were recorded.

4.2 RESULTS

Results of the maize shelling test operation was recorded as shown in the table 4.1.

Table 4.1 results of maize shelling

Operational runs	Number of Coconut dehusked	Number of well dehusked coconut	Number of fruits Not well dehusked	Time (seconds)	Efficiency (%)	Throughput Capacity (dehusked coconuts/h)
1	10	9	1	1140	90	32
2	10	8	2	1098	80	33
3	10	8	2	1100	80	33
Averages	10				83.3	33

Average time to shell maize (1140+ 1098 + 1100)/3 =1112 seconds

Throughput capacity of the maize thresher; $T_p = \frac{W_t}{t_T}$ (kg/hr) (3.10)

Mechanical Efficiency of maize thresher $e = \frac{W_a}{W_t} = \frac{\text{Total weight of dehusked coconut (output)}}{\text{Total weight of coconut loaded in machine (input)}}$

4.3 DISCUSSION

Test and results from the performance evaluation of the coconut dehusking machine showed that it was quite effective for deshelling various sizes of coconuts with a throughput capacity of 33 coconuts per hour. The efficiency of the machine was estimated as 83.3%. Effectiveness of the dehusking process is dependent on the dehusking force of the machine and the moisture content of the coconut fiber. A major advantage and achievement in this pprototype is that more than one coconut can be dehusked concurrently and dehusked coconut can be discharged automatically without the input of human effort.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The fabricated coconut dehusking machine was designed, fabricated and tested with satisfactory output. The improvements made in the machine include the self-discharge and multiple coconut dehusking. Varying sizes of coconut were dehusked with the use of the machine in a continuous fashion as long as the shelling power of the machine is not exceeded. Coconut is a popular food popular fruit in Nigeria with varieties of use, hence it will be rewarding and profitable to have such a functional machine in the urban and local regions of the country where farming is practiced. The machine was produced using locally sourced material. Major workshops manufacturing techniques were used for the production of the machine. The manufacturing processes used include; welding, cutting, machining, filing, drilling and painting.

5.2 RECOMMENDATIONS

The present research has been successfully completed with some improvements, however; the following recommendations were made as follows;

i. There is need for the commercialization of this prototype as it will serve as a viable farm too for coconut farmers.

ii. Further research and works are highly encouraged to refine the machine with better dehusking efficiency.

iii. Further research on an improved coconut dehusking machine with continuous self-loading, dehusking and discharge is encouraged.

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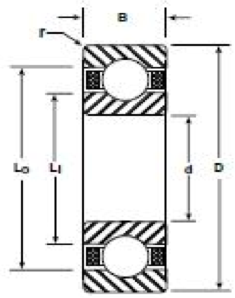
Appendix 3: Bearing design characteristics.

Ball Bearings

Metric Series
Radial

Bore Sizes 10-25 mm



BASIC P/N	BORE d		O.D. D		WIDTH B		LAND DIAMETER (REFERENCE)		FILLET RADIUS r	BALL COMPLEMENT		LOAD RATINGS LBS	
							L_i	L_o		NO.	SIZE	DYN. C	STATI C_o
	mm	INCH	mm	INCH	mm	INCH	INCH	INCH	INCH		INCH		
R-1900	10	.3937	22	.8661	6	.2362	.570	.734	.012	9	1/8	580	280
R-100	10	.3937	26	1.0236	8	.3150	.583	.837	.012	7	3/16	1000	440
R-200	10	.3937	30	1.1811	9	.3543	.656	.919	.024	7	7/32	1300	580
R-300	10	.3937	35	1.3780	11	.4331	.717	1.055	.024	6	9/32	1800	770
R-1901	12	.4724	24	.9449	6	.2362	.629	.800	.012	9	9/64	730	350
R-101	12	.4724	28	1.1024	8	.3150	.670	.900	.012	7	3/16	1000	460
R-201	12	.4724	32	1.2598	10	.3937	.725	1.007	.024	7	15/64	1500	670
R-301	12	.4724	37	1.4567	12	.4724	.777	1.153	.039	6	5/16	2150	930
R-1902	15	.5906	28	1.1024	7	.2756	.735	.972	.012	10	5/32	940	490
R-102	15	.5906	32	1.2598	9	.3543	.803	1.048	.012	9	3/16	1250	630
R-202	15	.5906	35	1.3780	11	.4331	.815	1.153	.024	7	1/4	1700	790
R-302	15	.5906	42	1.6535	13	.5118	.934	1.310	.039	7	5/16	2500	1200
R-1903	17	.6693	30	1.1811	7	.2756	.810	1.032	.012	11	5/32	1000	550
R-103	17	.6693	35	1.3780	10	.3937	.910	1.140	.012	10	3/16	1300	710
R-203	17	.6693	40	1.5748	12	.4724	.952	1.292	.024	8	17/64	2100	1050
R-303	17	.6693	47	1.8504	14	.5512	1.017	1.495	.039	7	11/32	3000	1450
R-1804	20	.7874	32	1.2598	7	.2756	.948	1.098	.012	14	1/8	750	480
R-1904	20	.7874	37	1.4567	9	.3543	.995	1.262	.012	9	7/32	1600	860
R-104	20	.7874	42	1.6535	12	.4724	1.075	1.375	.024	8	1/4	1900	990
R-204	20	.7874	47	1.8504	14	.5512	1.131	1.507	.039	8	5/16	2850	1450
R-304	20	.7874	52	2.0472	15	.5906	1.192	1.643	.043	7	3/8	3550	1750
R-1805	25	.9843	37	1.4567	7	.2756	1.145	1.295	.012	17	1/8	820	600
R-1905	25	.9843	42	1.6535	9	.3543	1.195	1.460	.012	11	7/32	1850	1100
R-105	25	.9843	47	1.8504	12	.4724	1.267	1.567	.024	10	1/4	2200	1300
R-205	25	.9843	52	2.0472	15	.5906	1.328	1.703	.039	9	5/16	3100	1750
R-305	25	.9843	62	2.4409	17	.6693	1.450	1.976	.039	7	15/32	4750	2450

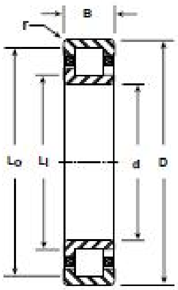
Notes:

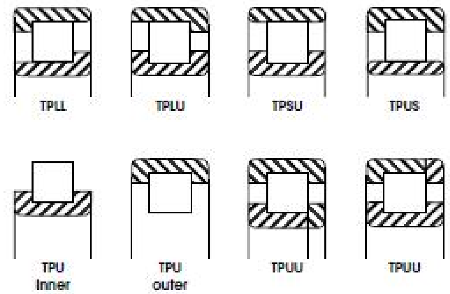
1. Metric series radial ball bearings are typically manufactured from 52100 chrome steel to ABEC 3, 5 and 7 tolerances per ABMA Standard 20.
2. Fillet Radius (r) is the maximum shaft or housing fillet radius that bearing corners will clear.

Metric Series

Bore Sizes 10-25 mm

TPUL





BASIC P/N	BORE d		O.D. D		WIDTH B		NOMINAL ROLLER PATH DIA.		MOUNTING SHOULDER DIA.		FILLET RADIUS r	ROLLER		LOAD RATINGS LBS	
							INNER	OUTER	MIN. SHAFT L_i	MAX. HOUSING L_o		NO.	DIA. & LENGTH	DYN. C	STATIC C_o
	mm	INCH	mm	INCH	mm	INCH	INCH	INCH	INCH	INCH	INCH		mm		
TP1900	10	.3937	22	.8661	6	.2362	.4923	.7679	.472	.788	.012	10	3.5	1100	790
TP100	10	.3937	26	1.0236	8	.3150	.5116	.9053	.482	.929	.012	8	5	1800	1250
TP200	10	.3937	30	1.1811	9	.3543	.5910	.9847	.558	1.025	.024	8	5	1800	1250
TP300	10	.3937	35	1.3780	11	.4331	.6694	1.1812	.571	1.202	.024	8	6.35	2900	2000
TP1901	12	.4724	24	.9449	6	.2362	.5777	.8532	.559	.862	.012	10	3.5	1100	810
TP101	12	.4724	28	1.1024	8	.3150	.5909	.9846	.560	1.016	.012	8	5	1800	1250
TP201	12	.4724	32	1.2598	10	.3937	.6299	1.1024	.616	1.116	.024	8	6	2500	1750
TP301	12	.4724	37	1.4567	12	.4724	.7103	1.2615	.676	1.263	.039	8	7	3400	2400
TP1902	15	.5906	28	1.1024	7	.2756	.7088	.9844	.678	1.027	.012	14	3.5	1400	1200
TP102	15	.5906	32	1.2598	9	.3543	.7382	1.1319	.682	1.166	.012	10	5	2150	1650
TP202	15	.5906	35	1.3780	11	.4331	.7485	1.2210	.737	1.239	.024	10	6	2950	2250
TP302	15	.5906	42	1.6535	13	.5118	.8229	1.4529	.792	1.452	.039	8	8	4400	3200
TP1903	17	.6693	30	1.1811	7	.2756	.7877	1.0633	.742	1.107	.012	14	3.5	1400	1200
TP103	17	.6693	35	1.3780	10	.3937	.8366	1.2303	.767	1.288	.012	12	5	2450	2050
TP203	17	.6693	40	1.5748	12	.4724	.8782	1.3900	.811	1.425	.024	10	6.35	3600	2850
TP303	17	.6693	47	1.8504	14	.5512	.9232	1.6319	.872	1.640	.039	8	9	5400	4000
TP1804	20	.7874	32	1.2598	7	.2756	.8858	1.1614	.879	1.172	.012	16	3.5	1550	1400
TP1904	20	.7874	37	1.4567	9	.3543	.9352	1.3289	.878	1.371	.012	14	5	2750	2450
TP104	20	.7874	42	1.6535	12	.4724	.9449	1.4961	.922	1.519	.024	10	7	4000	3250
TP204	20	.7874	47	1.8504	14	.5512	1.0199	1.6498	.975	1.667	.039	10	8	5200	4250
TP304	20	.7874	52	2.0472	15	.5906	1.0235	1.8109	.994	1.849	.039	8	10	6650	5050
TP1805	25	.9843	37	1.4567	7	.2756	1.0847	1.3583	1.060	1.380	.012	18	3.5	1700	1600
TP1905	25	.9843	42	1.6535	9	.3543	1.1429	1.5366	1.075	1.569	.012	16	5	3050	2850
TP105	25	.9843	47	1.8504	12	.4724	1.1419	1.6931	1.131	1.702	.024	12	7	4600	4050
TP205	25	.9843	52	2.0472	15	.5906	1.2003	1.8303	1.151	1.861	.039	12	8	5950	5300
TP305	25	.9843	62	2.4409	17	.6693	1.3211	2.1873	1.206	2.223	.039	10	11	9300	7750

Notes:

1. NHBB typically manufactures roller bearings in both 52100 and M50 material to ABEC 5 tolerances per ABMA Standard 20. Other materials and tolerances are available.
2. All cages are metallic and one-piece machined.
3. Standard rollers have equal length and diameter. Rectangular rollers, typically under a 2:1 length-to-diameter ratio, are also available.
4. Custom features such as puller grooves, mounting flanges and anti-rotation devices can be designed into all ring configurations.
5. Fillet Radius (r) is the maximum shaft or housing fillet radius that bearing corners will clear.